DEVELOPMENT AND CHARACTERISATION OF POLYMER ELECTROLYTES AND THEIR APPLICATION IN ENERGY DEVICE

FINAL -SYNOPSIS

OF THE Ph.D. THESIS TO BE SUBMITTED

TO

MANGALORE UNIVERSITY

FOR THE AWARD OF DEGREE OF

DOCTOR OF PHILOSOPHY

IN

CHEMISTRY

BY

SUMANA V S

DEPARTMENT OF STUDIES AND RESEARCH IN CHEMISTRY
MANGALORE UNIVERSITY
MANGALAGANGOTHRI – 574199

DECEMBER- 2022

Name of Candidate:	SUMANA V S
Title of the Thesis:	DEVELOPMENT AND CHARACTERISATION OF POLYMER ELECTROLYTES AND THEIR APPLICATION IN ENERGY DEVICE
Name of the Guide:	PROFESSOR Dr. G. K. NAGARAJA
Name of the Institution:	DEPARTMENT OF STUDIES AND RESEARCH IN CHEMISTRY, MANGALORE UNIVERSITY, MANGALAGANGOTHRI – 574199
Registration No:	MU/EXB/Ph.D./CR.203/Chem./2018-19/E.13:23-02-2019
Registration Date:	02-03-2017

Date of Pre-colloquium held: **26-11-2022**

Introduction

Sustainable energy supplies and storage will be the futuristic solution to overcome the dependence on raw or refined hydrocarbons which on ignition supplies energy. Within a decade, the upcoming demand for energy storage systems based on their increasing usage from portable devices to large scale grid systems is going to increase two-fold. Moreover, the exhaustion of fossil fuels and increasing environmental concern will add up the stress on low-carbon sustainable energy technology researchers to decrypt the renewable jigsaw piece. This piece must resolve client demand, scalability, portability, efficiency, low-carbon footprint etc., whilst the cost initially might be higher but can be less or equivalent to other non-renewable energy sources. Electrical energy storage and technique is one among the broad variety of renewable energy generation techniques that competes for the position in the sustainable aspect of the future. This device may not be the only jigsaw piece that can address the energy demand. Futuristic technologies will make use of solar, hydro and wind for the generation and storage of energy. So, a multipronged portfolio approach along with electrical energy storage systems is the key to meeting the demand during the energy crisis.

Among all these trends today the main option for large-scale energy storage are pumped hydro storage and batteries. When it comes to portability, the most preferable energy devices are supercapacitors and batteries. Batteries like lithium-ion batteries offer high energy density and are widely used in electronic devices. However, as safety is concerned the operation of Li-ion battery at high power leads to internal heat generation due to resistive loss from dendrite formation and slow electron movement [1]. Due to high production to demand ratio of grid scale battery setup makes it affordable to meet the energy requirements. Contrastingly, the supercapacitor is blooming as a complement or replacement of batteries in sectors that demand high power density, high cycle life, fast charging, grid-scale power stability and enhanced power to weight ratio.

Classification of supercapacitor

Depending on functionality and types of materials used in a supercapacitor, it is mainly classified as shown in Fig. 1

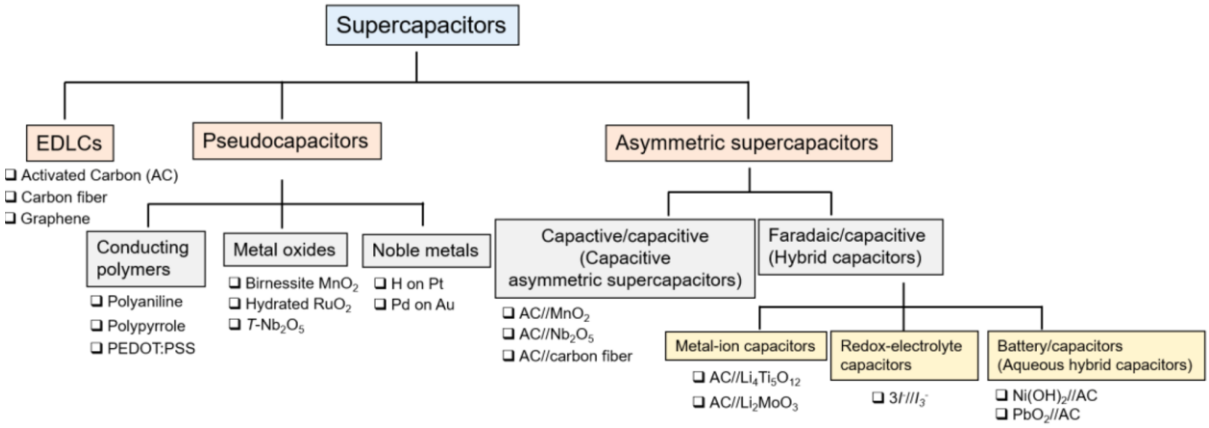


Figure 1. Classification of supercapacitors. Reproduced with permission from ref[1], ACS publication

Fundamentally, electrical energy is stored in two different ways in energy devices: (a) indirectly, with chemical energy converting to electric energy generated from electroactive materials undergoing a faradic redox reaction between two electrodes having different electrode potentials, and (b) directly, with non-faradic, that is, electric energy stored in an electrostatic way between negative and positive electrodes separated by a dielectric medium. Electrochemical cells are devices that convert chemical energy into electrical energy and vice versa. Due to the redox reaction in the electrode-electrolyte interface, this electrical energy can be obtained. The electrochemical cells mainly consist of a negative electrode and a positive electrode having active mass and an ion-conducting electrolyte. In response to the changing global landscape, energy has become a primary focus of the major world powers as well as the scientific community[2]. The exploration story of the charge-discharge mechanism started in the middle of the 18^{th} century from Leyden jar and to major three classes of supercapacitor in the 21st century (Fig. 2).

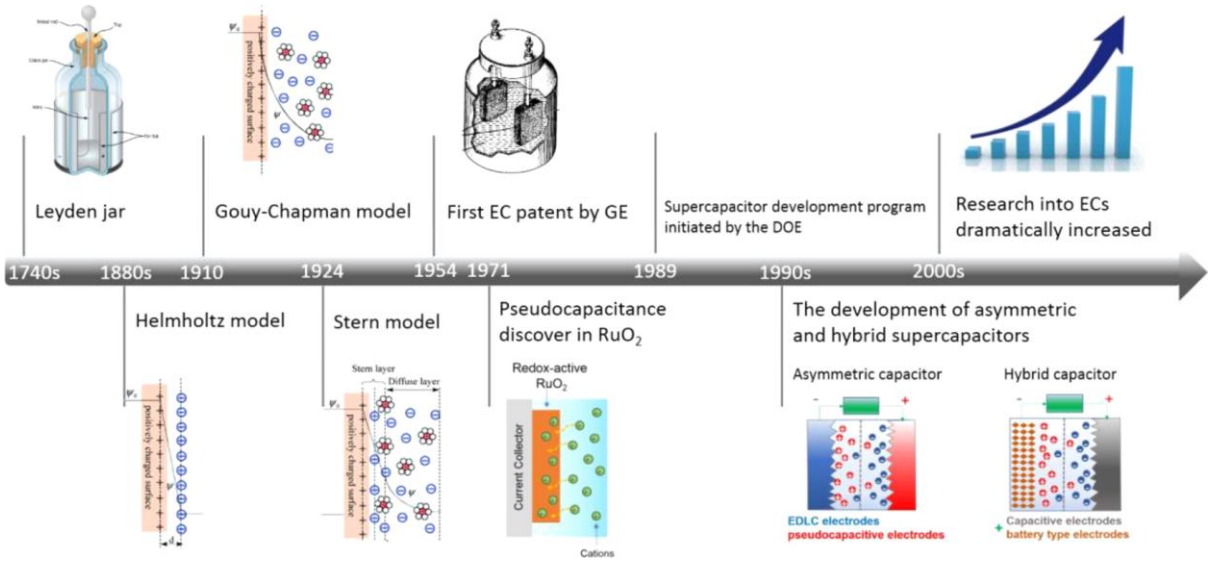


Fig. 2. Historic timeline for the development of supercapacitors. Reproduced with permission from ref[1], ACS publication

Designing an electrolyte for use in a supercapacitor is based on its performance expectations. The main indicators are similar to electrode materials are capacitance, voltage window, charge storage time constants, characteristic resistances, rate performance, cyclability, and safety. Furthermore, factors affecting the electrode/electrolyte interface region and the bulk of electrolytes such as ionic conductivity and mobility, diffusion coefficient, the radius of hydrated spheres, solvation, dielectric constant, electrochemical stability, thermal stability, and dispersion interaction as to be studied before designing an optimized electrolyte[3]. Fig. 3 shows the classification of electrolytes used in supercapacitor application

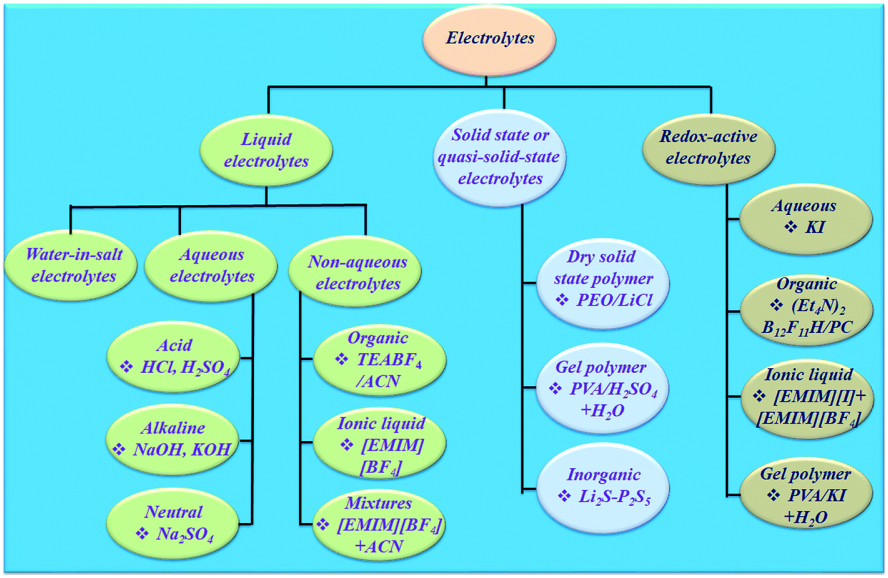


Figure 3. Classification of electrolytes for electrochemical supercapacitors[3]

To bridge the gap between electrode material and polymer electrolyte we have prepared inorganic salt doped polymer electrolyte and modified electrode to understand the synergy between them. This thesis work includes seven chapter, including five working chapters.

Chapter 1: General Introduction

Chapter 2: Experimental Section

- Characterization
- Fabrication of Supercapacitor and characterization

Chapter 3: Miscibility studies of gaur gum and polyvinyl alcohol

Chapter 4: Development of guar gum (GG)/poly(vinylalcohol) (PVA) blend biodegradable electrolyte for supercapacitor application

Chapter 5: Biodegradable blend film derived from Polycaprolactone and guar gum blend for packaging and energy storage application

Chapter 6: Development of poly(styrene sulfonic acid) (PSSA) and guar gum (GG) electrolyte for supercapacitor application

Chapter 7: Development of Pt nanoflower-Poly(aniline) electrode material with the synchronized concept of energy storage in supercapacitor

Thesis Organization

Chapter 1: General Introduction

Chapter 1 deals with general introduction on importance, development of polymer electrolytes and supercapacitors. A brief literature survey on electrode materials and polymer electrolytes for application in supercapacitor have been included.

Chapter 2:

Chapter 2 describes the experimental section, brief introduction on various characterization techniques and fabrication of supercapacitor and its characterization.

Chapter 3:

Miscibility studies of gaur gum and polyvinyl alcohol

Miscibility studies of Guar gum (GG) /PVA blend polymer solution were performed as follows

- Solutions were prepared with different blend ratio to obtain desired property
- Viscometric method was used to calculate the interaction parameters at 30, 40 and 50 °C.
- Density of the solutions was measured at 30, 40 and 50 °C.
- Refractive index of the solutions was measured at 30, 40 and 50 °C and predicted the miscibility of the solution.
- Films of GG/PVA blend polymer electrolytes with different ratios. Varying amounts of polyphosphoric acid and $LiClO_4$ were used as dopants by maintaining the smooth and clear film property with enhanced mechanical property.

Chapter 4:

Development of guar gum (GG)/poly(vinylalcohol) (PVA) biodegradable electrolyte for supercapacitor application

In the present work, the ionic resistance in the activated carbon (AC) electrode and blend polymer electrolyte (BPE) interface is reduced by tuning binder and BPE. A unique microcannulars channel connecting AC, binder and gaur gum (GG)/polyvinylalcohol (PVA) electrolyte is developed for easy Li^+ movement. The use of AC derived from areca nut and natural GG as a binder makes the developed method more environmentally sustainable. The

presence of microcannular structures on the electrode surface and BPE was confirmed using SEM and TEM analysis. Combined DSC-TGA data for BPE showed that PVA provides the mechanical support to jelly guar gum. The ionic conductivity, activation energy, dielectric studies were studied to understand the electrode/electrolyte interface mechanism. Dielectric studies revealed that the unique pathway of microcannular structures reduces the charge transfer resistance significantly at the interface. Optimized BPE was used in the fabrication of supercapacitor and specific capacitance was found to be 542 Fg^{-1}. The time constant was 0.4 s and showed consistent cyclic pattern during galvanostatic charge/discharge studies with 99% Columbic efficiency.

Chapter 5:

Biodegradable blend film derived from polycaprolactone and guar gum blend for packaging and energy storage application.

In the present work the biodegradable polymeric material include a synthetic biodegradable polymer and natural gum with or without additives. The film is comprised of polycaprolactone (PCL) and gaur gum. 5-15 percent by weight additives such as anti-oxidant agents, softening agents, preservatives, colouring agents, anticraking agents, and firming agents, were used as per to get the desired property. The drawbacks of polycaprolactone in the biomedical application are having poor bioavailability property for drugs. This property is enhanced by blending PCL with natural gums which gelates easily in water. The PCL forms a brittle film at higher concentrations and lose its mechanical strength, nonetheless blending with natural gum provides flexible and softness to the film. The stock solution of the polymers can include between 2-7% (wt/v) of PCL and 2-5% (wt/v) of guar gum. Films were prepared by blending PCL and guar gum in different ratios ranging from 90:10 to 10:90, respectively. The thermal, surface morphology, tensile strength of the films were determined. The blend displays a unique tubular array in the polymer matrix. This unique tubular array of blend polymer matrix provides softness, flexibility, sufficient tensile strength and binding property. The film may also contain additives based on application demand. The existing procedures in the published inventions not only reduce the productivity but also increases the time and cost simultaneously. The need therefore has arisen to develop a blend film having property of softness, elasticity, sustainability, biodegradability, and robustness.For supercapacitor, the blend films were prepared by mixing the GG/PCL in the ratio 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 10:90. $LiClO_4$ concentration was optimized and 0.1 wt% of blend solution was added for preparation blend polymer electrolyte

(BPE). The solution was casted on petri plates and dried to get film. The BPE was characterized using TGA/DSC, SEM, FTIR, conductivity and dielectric studies. Supercapacitor was fabricated and electrochemical studies were performed. Optimized BPE was used in fabrication of supercapacitor and specific capacitance was found to be 365 Fg^{-1}. The time constant was 0.8 s and showed consistent cyclic pattern during galvanostatic charge/discharge studies with 97% Columbic efficiency. The polymeric blend film can be used in packing industries and lithium salt doped supercapacitor.

Chapter 6:

Development of poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) and guar gum (GG) electrolyte for use in supercapacitor

In the present work, gel polymer electrolyte (GPE) was prepared using poly(3,4-ethylenedioxythiophene) polystyrene sulfonate and guar gum (GG). Combined DSC-TGA data for GPE showed that PSSA provides the mechanical support and proton conducting matrix to jelly guar gum. The ionic conductivity, activation energy, dielectric studies were studied to understand the electrode/electrolyte interface mechanism. Dielectric studies revealed that the unique pathway of proton transfer within the guar gum structures reduces the charge transfer resistance significantly at the interface. Optimized GPE was used in the fabrication of supercapacitor and specific capacitance was found to be 241 Fg^{-1}. The time constant was 0.3s and showed consistent cyclic pattern during galvanostatic charge/discharge studies with 99% Columbic efficiency.

Chapter 7:

Development of Pt nanoflower-Poly(aniline) electrode material with the synchronized conceptof energy storage in supercapacitor

Electrochemically deposited porous film of poly(aniline) (PANI) on stainless steel (SS) current collector is employed as the support for electrodeposition of platinum (Pt). PANI facilitates the formation of Pt nanoflowers with an enhanced electrochemically active surface area compared with sub-micron size Pt particles deposited on the bare SS electrode. Hence, a new concept Pt nanoflower-PANI electrode materials with synchronization between redox mode in PANI and double-layer mode of charge storage in Pt nanoflower is discussed. Remarkably, Pt is distributed like a nano-flower on the surface of PANI and prevents PANI

from stripping during the charge-discharge process, thereby minimizing the issue of stripping in conducting polymer-based electrodes. Owing to the highly porous surface morphology of Pt nanoflowers as observed in SEM, the Pt-PANI/SS electrode shows excellent electrochemical performance than PANI/SS electrode towards supercapacitor application. The electrode materials are characterized using X-ray and X-ray photon spectroscopy (XPS), which shows dual amorphous and crystalline properties. Dielectric studies of Pt-PANI/SS electrodes were carried out to understand electrode/electrolyte interface behavior. In the fabricated supercapacitor, the cyclic voltammetry studies showed quasi-rectangular shape characteristics at slower scan rates with a specific capacitance of 926 Fg^{-1}. Charge-discharge studies showed good cyclic stability and coulombic efficiency

Summary and Conclusions:

The prepared polymer electrolytes were well characterized via different analytical, microscopic and electrochemical techniques. The polymer electrolytes were used in fabrication of supercapacitor and performed its electrochemical studies. The conclusions drawn from whole study has been reported.

References

1. Y. Shao *et al.*, "Design and Mechanisms of Asymmetric Supercapacitors," *Chem. Rev.*, vol. 118, no. 18, pp. 9233–9280, Sep. 2018, doi: 10.1021/acs.chemrev.8b00252.
2. Y. Sudhakar, M. Selvakumar, and D. K. Bhat, *Biopolymer electrolytes: Fundamentals and applications in energy storage*. Elsevier, 2018.
3. B. Pal, S. Yang, S. Ramesh, V. Thangadurai, and R. Jose, "Electrolyte selection for supercapacitive devices: a critical review," *Nanoscale Adv.*, vol. 1, no. 10, pp. 3807–3835, 2019, doi: 10.1039/C9NA00374F.

Electrochimica Acta 353 (2020) 136558

Contents lists available at ScienceDirect

Electrochimica Acta

journal homepage: www.elsevier.com/locate/electacta

Microcannular electrode/polymer electrolyte interface for high performance supercapacitor

V.S. Sumana [a, c], Y.N. Sudhakar [b], Varghese Anitha [b], G.K. Nagaraja [c, *]

[a] Department of Chemistry, Srinivas Institute of Technology, Valachil, 574143, India
[b] Department of Chemistry, Christ (Deemed to be University), Bengaluru, India
[c] Department of Chemistry, Mangalore University, Mangalagangotri, Konaje, India

ARTICLE INFO

Article history:
Received 7 April 2020
Received in revised form
27 May 2020
Accepted 31 May 2020
Available online 7 June 2020

Keywords:
Mesoporous material
Nanotubules
Natural binder
Biodegradable polymer electrolyte
Supercapacitor

ABSTRACT

In the present work, the ionic resistance in the activated carbon (AC) electrode and blend polymer electrolyte (BPE) interface is reduced by tuning binder and BPE. A unique microcannulars channel connecting AC, binder and gaur gum (GG)/polyvinylalcohol (PVA) electrolyte is developed for easy Li^+ movement. The use of AC derived from areca nut and natural GG as a binder makes the developed method more environmentally sustainable. The presence of microcannular structures on the electrode surface and BPE was confirmed using SEM and TEM analysis. Combined DSC-TGA data for BPE showed that PVA provides the mechanical support to jelly guar gum. The ionic conductivity, activation energy, dielectric studies were studied to understand the electrode/electrolyte interface mechanism. Dielectric studies revealed that the unique pathway of microcannular structures reduces the charge transfer resistance significantly at the interface. Optimized BPE was used in the fabrication of supercapacitor and specific capacitance was found to be 542 Fg^{-1}. The time constant was 0.4 s and showed consistent cyclic pattern during galvanostatic charge/discharge studies with 98% Columbic efficiency.

© 2020 Elsevier Ltd. All rights reserved.

1. Introduction

Solid polymer electrolytes (SPE) suitable for storing energy generated from renewable sources such as solar, wind, and waves from the ocean [1] are in limelight among researchers. SPE provides enhanced energy capacity, cyclability, flexibility, non-flammability, better handling and leak-proof features compared to conventional liquid electrolyte based energy devices [2]. Presently, lithium ion-doped polymers have gained market in the field of energy devices due to high energy density and stability. Doping of lithium ions (Li^+) is curial because both Li^+ and its counter anion migrate during charging and discharging, producing irreversible by-products. Moreover, the transport number of Li^+ is less than 0.3 in contrast to its counter ion which moves faster than Li^+ [3]. This implies that compared to the hopping mechanism of Li^+, the anions can move faster but, this movement has no influence on the overall current as they do not involve in electrode reactions [4]. Additionally, the accumulation of a large number of anions will affect the polarization potential and electrode/electrolyte interface [5,6]. On providing a channel for easy movement of Li^+ ions near the electrode/electrolyte interface region, the energy density and power density during charging and discharging would be enhanced. This new concept of introducing channels in the electrode material matrix for the movement of Li^+ showed a significant change in the specific capacitance of supercapacitor in this present work.

Supercapacitors are the devices that have their energy density and power density between capacitor and battery [7]. Few ultracapacitors are already in the market [8,9], but, tuning of polymer-based ultracapacitor/supercapacitors is yet to establish their role in providing efficient devices. Fillers like graphene oxides were reinforced into poly(4-styrene sulfonic acid)/PVA blend matrix has resulted in the enhancement of dielectric constant [10]. Hence, a proper binder with AC electrode material and solid polymer electrolyte would certainly enhance the dielectric constant for portable and flexible energy devices. The role of different binders is significant in electrochemical performance in energy devices wherein binders amazingly enhance the cycle stability, kinetics of ions at the electrodes and bonding capacity [11]. Least attention has been given to binders as to how they improve the properties and mechanical integrity of electrodes in energy devices [12]. Dominic et al. [13] reviewed on most recent developments in the field of green binders for batteries and supercapacitors and explained how

* Corresponding author.
E-mail address: nagarajagk@gmail.com (G.K. Nagaraja).

https://doi.org/10.1016/j.electacta.2020.136558
0013-4686/© 2020 Elsevier Ltd. All rights reserved.

Applied Surface Science 589 (2022) 152994

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Full Length Article

Pt nanoflower-poly(aniline) electrode material with the synchronized concept of energy storage in supercapacitor

V.S. Sumana [a,d], Y.N. Sudhakar [b,*], Anitha Varghese [c], G.K. Nagaraja [d,*]

[a] Department of Chemistry, Srinivas Institute of Technology, Valachil 574143, India
[b] Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal 576104, Karnataka, India
[c] Department of Chemistry, CHRIST (Deemed to be University), Bengaluru 560029, India
[d] Department of Chemistry, Mangalore University, Mangalagangotri, Konaje, India

ARTICLE INFO

Keywords:
Poly(aniline)
Platinum
Nanomaterial
Dielectric
XPS
Supercapacitor

ABSTRACT

Electrochemically deposited porous film of poly(aniline) (PANI) on stainless steel (SS) current collector is employed as the support for electrodeposition of platinum (Pt). PANI facilitates the formation of Pt nanoflowers with an enhanced electrochemically active surface area compared with sub-micron size Pt particles deposited on the bare SS electrode. Hence, a new concept Pt nanoflower-PANI electrode materials with synchronization between redox mode in PANI and double-layer mode of charge storage in Pt nanoflower is discussed. Remarkably, Pt is distributed like a nano-flower on the surface of PANI and prevents PANI from stripping during the charge-discharge process, thereby minimizing the issue of stripping in conducting polymer-based electrodes. Owing to the highly porous surface morphology of Pt nanoflowers as observed in SEM, the Pt-PANI/SS electrode shows excellent electrochemical performance than PANI/SS electrode towards supercapacitor application. The electrode materials are characterized using X-ray and X-ray photon spectroscopy (XPS), which shows dual amorphous and crystalline properties. Dielectric studies of Pt-PANI/SS electrodes were carried out to understand electrode/electrolyte interface behavior. In the fabricated supercapacitor, the cyclic voltammetry studies showed quasi-rectangular shape characteristics at slower scan rates with a specific capacitance of 926 Fg^{-1}. Charge-discharge studies showed good cyclic stability and coulombic efficiency.

1. Introduction

The scientific world and the majority of industries are keenly oriented towards developing efficient energy accumulators. Supercapacitors are devices belonging to this energy-efficient category. The advancement of supercapacitors in the electronics and automobiles field has improved based on the understanding of electrical double layer that accumulates charges on the electrode surface and stores them at the bulk of the layer. To overcome the time delay of orientation polarization at the electrode-electrolyte interface, the chemical reaction at the surface has to be reduced. Two methods followed in modern electrochemistry for this are solid polymer electrolyte [1] and conducting polymers-based hybrid supercapacitors. Incorporating conducting material enhances specific energy due to reversible redox reactions occurring in conducting polymer at the interface [2].

Poly (aniline) is a conducting polymer that has been extensively studied in supercapacitors as it exhibits reversible insulator-to-metal transitions and electrochromic behavior depending on variable oxidation states and pH. Stability towards air and humidity by PANI makes it suitable for energy applications [3]. PANI nanowire arrays grown on 3D graphene provided a shorter ion diffusion path and larger contact area with the electrolyte [4–7]. Electrochemical impedance studies revealed that PANI films prepared by the potentiodynamic method of electrodeposition produced high specific conductance and resistance [8]. Hence, the cyclic voltammetric deposition of PANI was employed for the present investigation. Nonetheless, PANI is prone to peeling off the deposited surface during the charge-discharge cycle. Moreover, composites prepared using PANI showed higher capacitance and stability than the individual counterparts [9]. Composites like reduced graphene oxide/g-C_3N_4/Ag_2O nano-structure when uniformly distributed on PANI surface increased the specific capacitance from 105 Fg^{-1} for polyaniline to 175 Fg^{-1} for composite [10]. Composites are prepared by a physical mixture of conducting polymer with materials like metal nanoparticles, carbon powder, graphite fibers, metal-imbedded glass fibers, and other

* Corresponding authors.
E-mail addresses: sudhakar.yn@manipal.edu (Y.N. Sudhakar), nagarajagk@gmail.com (G.K. Nagaraja).

https://doi.org/10.1016/j.apsusc.2022.152994
Received 24 November 2021; Received in revised form 28 February 2022; Accepted 1 March 2022
Available online 3 March 2022
0169-4332/© 2022 Elsevier B.V. All rights reserved.

(12) PATENT APPLICATION PUBLICATION
(19) INDIA
(22) Date of filing of Application :22/03/2021

(21) Application No.202141012114 A
(43) Publication Date : 02/04/2021

(54) Title of the invention : BIODEGRADABLE BLEND FILM DERIVED FROM POLYCAPROLACTONE AN GUAR GUM BLEND FOR PACKAGING APPLICATION

(51) International classification	:C08J0005180000, C08L0067040000, C08L0023080000, C08J0007040000, A45D0040260000
(31) Priority Document No	:NA
(32) Priority Date	:NA
(33) Name of priority country	:NA
(86) International Application No	:NA
Filing Date	:NA
(87) International Publication No	: NA
(61) Patent of Addition to Application Number	:NA
Filing Date	:NA
(62) Divisional to Application Number	:NA
Filing Date	:NA

(71)**Name of Applicant :**
1)SUDHAKAR Y. N.
Address of Applicant :Department of Chemistry, CHRIST (Deemed to be University), Hosur Road, Bengaluru, Karnataka, India 560029. Karnataka India
2)SUMANA V. S.
3)ANITHA VARGHESE
4)NAGARAJA G. K.
(72)**Name of Inventor :**
1)SUDHAKAR Y. N.
2)SUMANA V. S.
3)ANITHA VARGHESE
4)NAGARAJA G. K.

(57) Abstract :
NA

No. of Pages : 12 No. of Claims : 10

DEPARTMENT OF STUDIES IN CHEMISTRY

MANGALORE UNIVERSITY

MANGALAGANGOTHRI - 574199, KARNATAKA, INDIA

ICCM 2019

International Conference on
Advances in Chemical and Materials Sciences
October 17-19, 2019

Certificate

This certificate is awarded to

Prof/Dr/Mr/Mrs/Ms. Sumana V. S.

Department of Chemistry, Srinivas Institute of Technology, Valachil, Mangalore

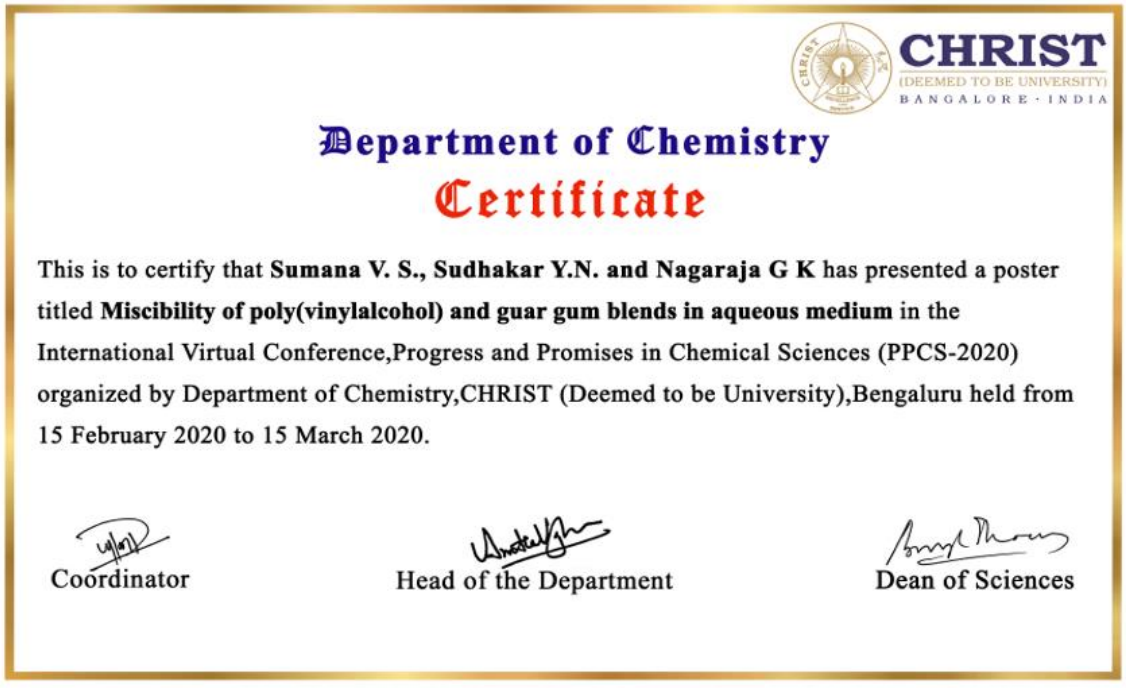
for participating as Poster Presenter *in International Conference on*

Advances in Chemical and Materials Sciences
held in the Department of Chemistry, Mangalore University during October 17 - 19, 2019.

Prof. Boja Poojary
Organizing Secretary, ICCM - 2019

Prof. G. K. Nagaraja
Chairman, ICCM - 2019

Prof. P. S. Yadapadithaya
Vice Chancellor



CHRIST
(DEEMED TO BE UNIVERSITY)
BANGALORE · INDIA

Department of Chemistry

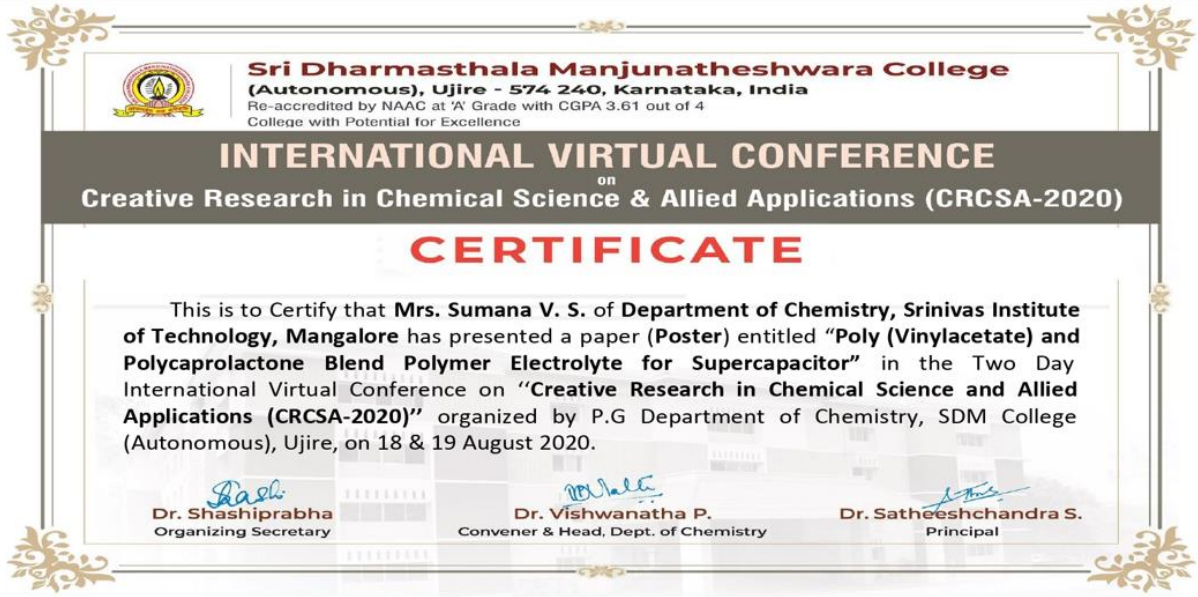
Certificate

This is to certify that **Sumana V. S., Sudhakar Y.N. and Nagaraja G K** has presented a poster titled **Miscibility of poly(vinylalcohol) and guar gum blends in aqueous medium** in the International Virtual Conference,Progress and Promises in Chemical Sciences (PPCS-2020) organized by Department of Chemistry,CHRIST (Deemed to be University),Bengaluru held from 15 February 2020 to 15 March 2020.

Coordinator

Head of the Department

Dean of Sciences



Sri Dharmasthala Manjunatheshwara College
(Autonomous), Ujire - 574 240, Karnataka, India
Re-accredited by NAAC at 'A' Grade with CGPA 3.61 out of 4
College with Potential for Excellence

INTERNATIONAL VIRTUAL CONFERENCE
on
Creative Research in Chemical Science & Allied Applications (CRCSA-2020)

CERTIFICATE

This is to Certify that **Mrs. Sumana V. S.** of **Department of Chemistry, Srinivas Institute of Technology, Mangalore** has presented a paper (**Poster**) entitled "**Poly (Vinylacetate) and Polycaprolactone Blend Polymer Electrolyte for Supercapacitor**" in the Two Day International Virtual Conference on "**Creative Research in Chemical Science and Allied Applications (CRCSA-2020)**" organized by P.G Department of Chemistry, SDM College (Autonomous), Ujire, on 18 & 19 August 2020.

Dr. Shashiprabha, Organizing Secretary
Dr. Vishwanatha P., Convener & Head, Dept. of Chemistry
Dr. Satheeshchandra S., Principal

SRINIVAS INSTITUTE OF TECHNOLOGY
VALACHIL, MANGALURU-574 143
(APPROVED BY AICTE, NEW DELHI. AFFILIATED TO VTU, BELGAVI, ACCREDITED BY NAAC)

INTERNATIONAL CONFERENCE ON RECENT TRENDS IN APPLIED SCIENCES
(ICRTAS - 2022)
ISBN : 978-81-956922-0-0

This is to certify that
Mrs. Sumana V S
has presented a paper entitled
Poly (Vinylidene Fluoride) and Gaur Gum Blend Polymer Electrolyte for Supercapacitor
at Two-Day ***International Conference on Recent Trends in Applied Sciences***
conducted on 3rd and 4th August 2022.

Dr. Shrinivasa Mayya D, *Principal, SIT*
Dr. Anant Kumar Kulkarni, *HOD, Mathematics*
Dr. Suryanarayana K, *HOD, Physics*
Dr. Gopalakrishna Bhat N, *HOD, Chemistry*

List of Publications

1. V. S. Sumana, Y. N. Sudhakar,Anitha Varghese,G. K. Nagaraja "Microcannular electrode/polymer electrolyte interface for high performance supercapacitor",Electrochimica Acta, 353, (2020), 136558.https://doi.org/10.1016/j.electacta.2020.136558

2. V. S. Sumana, Y. N. Sudhakar,Anitha Varghese,G. K. Nagaraja, Pt nanoflower-poly(aniline) electrode material with the synchronized concept of energy storage in supercapacitor, Applied Surface Science,589, (2022), 152994. https://doi.org/10.1016/j.apsusc.2022.152994

Patent Published:

1. **TITLE:** Biodegradable blend film derived from Polycaprolactone and guar gum blend for packaging application published on 02 April, 2021, Application ID 202141012114, Invention Field: Polymer technology, Publication Number 14/2021

Papers under considerations

1. Miscibility of poly(vinyl alcohol) and guar gum blends in aqueous medium
2. Poly(styrene sulfonic acid) (PSSA) and guar gum (GG) electrolyte for supercapacitor application

Conference Participation and presentation:

1. Participated and presented a paper title "Cannular electrode/electrolyte interface and blend polymer electrolyte for high performance supercapacitor" at International Conference on Advances in Chemical and Materials Science, October 17-19, 2019, Mangalore University, Konaje.
2. Participated and presented a paper title "Miscibility of poly(vinyl alcohol) and guar gum blends in aqueous medium" in International virtual Conference, progress and Promises in chemical science organised by Department of Chemistry, CHRIST(Deemed to be University)Bengaluru, from 15 February 2020 to 15 March 2020.
3. Participated and presented a paper title "'Poly (vinylacetate) and polycaprolactone blend polymer electrolyte for Supercapacitor' as E-Poster Presentation in the International Virtual Conference on 'Creative Research in Chemical Science and Allied applications' (CRCSA-2020) to be held on 18 & 19 August 2020.

4. Participated in International webinar on Frontier research in Chemical Sciences 2020 organized by Department of Chemistry, Mangalore University, Mangalagangothri during September 10-12, 2020.

5. Participated and presented a paper title 'Poly (vinylidene fluoride) and guar gum blend polymer electrolyte for Supercapacitor' in the Two day International Conference on recent trends in applied sciences conducted on 3rd and 4th August 2022, at Srinivas Institute of Technology, Valachil.

Prof. G. K. Nagaraja
(Research Guide)

Sumana V. S.
(Research Student)